ELDORADO MOUNTAINS G-E-M RESOURCES AREA

(GRA NO. NV-37)

TECHNICAL REPORT

(WSA NV 050-0423 and 050-0438)

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EXECUTIVE SUMMARY

The Eldorado Mountains Geology-Energy-Minerals (GEM) Resource Area (GRA) surrounds the town of Nelson, about 18 miles southeast of Las Vegas in Clark County, Nevada. It covers much of the Eldorado Mountains. There are two Wilderness Study Areas (WSAs): NV 050-0423 and NV 050-0438.

A small part of WSA NV 050-0423 is underlain by metamorphic rocks more than 600 million years old that are exposed much more extensively farther south, but most of the WSA is underlain by volcanic rocks about 15 million years old. In WSA NV 050-0438 there are large bodies of intrusive rocks of the 15 million year old group, intruded into metamorphic rocks of the much older group. There are numerous and complex faults. Known mineralization is related to the younger intrusive bodies.

The Eldorado Canyon mining district, which has produced $4.6 million (about $70 million at 1982 metal prices) in gold and silver lies between the two WSAs. The Searchlight district, which has produced about $6.2 million (about $90 million at 1982 metal prices) in gold, silver and lead, is a few miles southwest of the GRA. There are numerous patented claims in the GRA, most of them in the central parts of the mining districts and well outside the WSAs, but a few patented claims appear to lie either within or just adjacent to both WSAs. There are also numerous unpatented claims, some of which appear to lie within the WSAs. There are mineral leases just southeast of WSA NV 050-0438, in the adjacent Lake Mead Recreational Area.

There are numerous oil and gas leases in and near the GRA, and a few of these lie in the northern part of WSA NV 050-0423 or in the northern part of WSA NV 050-0438. There are no sodium and potassium leases or geothermal leases.

A small part of WSA NV 050-0423 adjacent to the Eldorado Canyon district is classified as having low favorability for metallic minerals with low confidence, and the remainder is classified as having low favorability with very low confidence. The entire WSA is classified for uranium as having moderate favorability with moderate confidence, and low favorability with low confidence for thorium. The entire WSA is classified as having low favorability for nonmetallic minerals with low confidence. Oil and gas and geothermal are both classified as low favorability with low confidence. There is no known potential for sodium or potassium, or for any other geological resources.

A small part of WSA NV 050-0438 is classified as having moderate favorability for metallic minerals with low confidence and the remainder is classified as having low favorability with very low confidence. Most of the WSA is classified as moderately favorable for uranium with moderate confidence, but two small areas are classified as having low favorability with low confidence. The

area has low favorability with low confidence for thorium. All of the WSA has low favorability for nonmetallic minerals, with low confidence. Oil and gas is classified as low favorability with very low confidence and geothermal as very low favorability with very low confidence. There is no known potential for sodium and potassium, or for any other geological resources.

BLM records should be checked to determine if certain claims lie within WSA NV 050-0423. Field work is recommended in both WSAs to determine if suspected areas of alteration are present.

I. INTRODUCTION

The Eldorado Mountains G-E-M Resources Area (GRA No. NV-37) contains approximately 110,000 acres (440 sq km) and includes the following Wilderness Study Areas (WSA):

WSA Name	WSA Number
El Dorado	NV 050-0423
Freteba Peaks	NV 050-0438

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Stateline/Esmeralda Resource Area, Las Vegas district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 35°45' north latitude, 114°50' west longitude and includes the following townships:

T 24 S, R 64,65 E	T 26 S, R 64,65 E
T 25 S, R 64,65 E	T 27 S, R 64,65 E

The areas of the WSAs are on the following U. S. Geological Survey topographic maps:

15-minute:

Nelson　　　　Boulder City

7.5-minute:

Boulder City, SE

The nearest town is Searchlight which is located about five miles southwest of the southwest corner of the GRA on U. S. Highway 95. Access to the area is via U. S. Highway 95 to the west. Access within the area is via unimproved dirt roads scattered throughout the GRA.

Figure 2 outlines the boundaries of the GRA and the WSAs on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

The WSAs in this GRA were not field checked.

One original copy of background data sepcifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included in the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

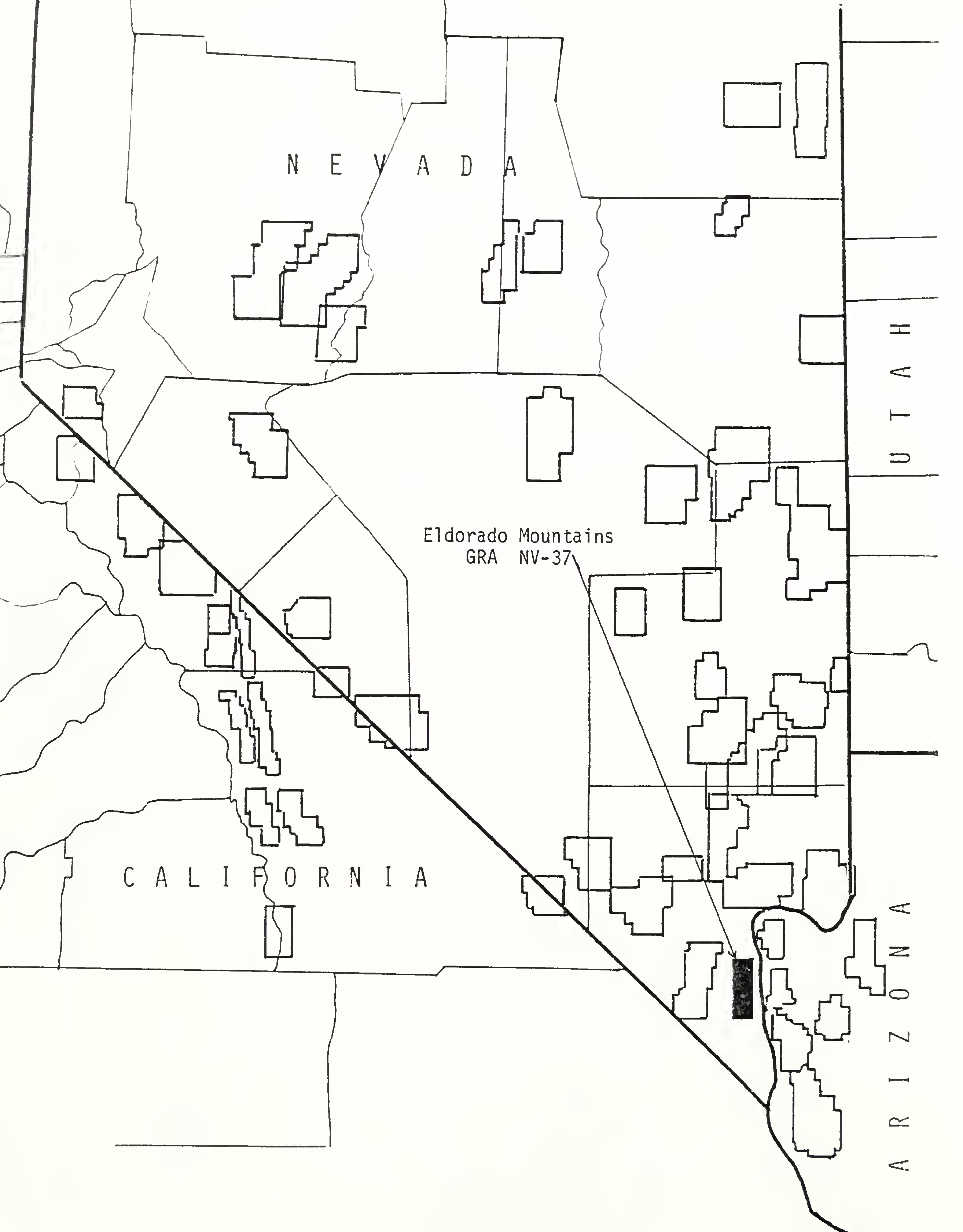
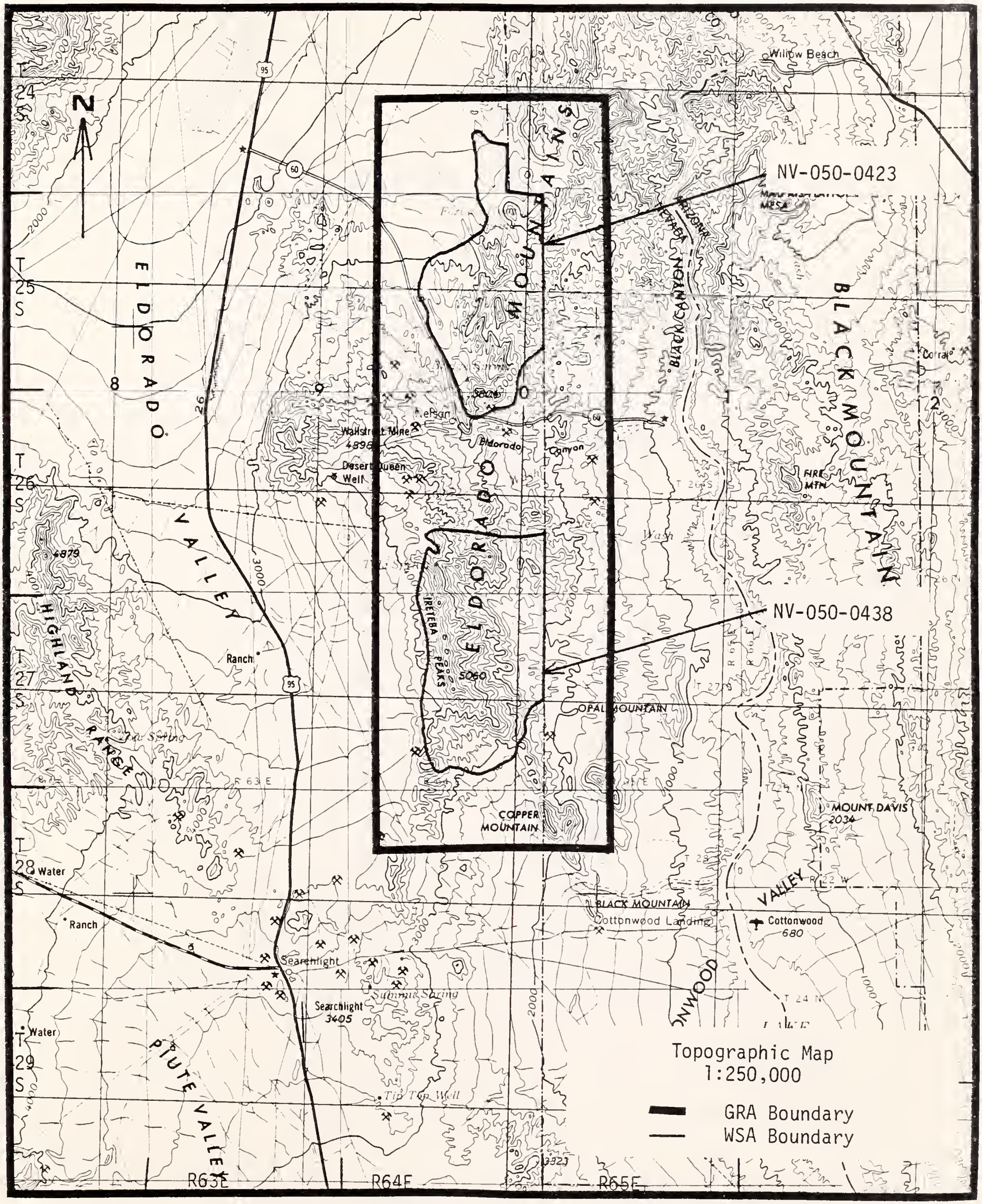


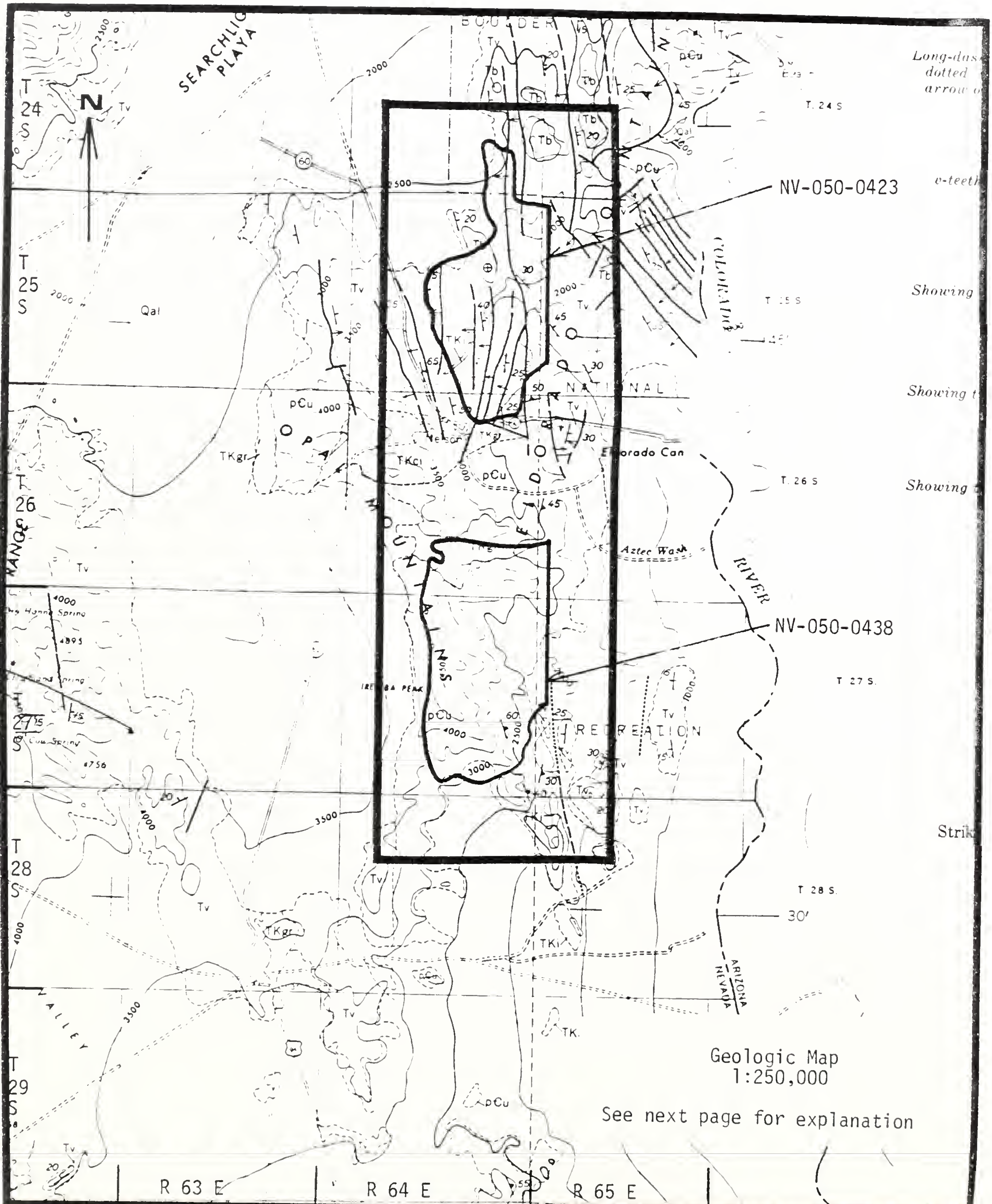
Figure 1. GRA Index Map of Region 3 1:3,168,000.



Kingman Sheet

Eldorado Mountains GRA NV-37

Figure 2



Longwell, Pampeyan, Bowyer
and Roberts (1965)

Eldorado Mountains GRA NV-37

Figure 3

EXPLANATION

CLARK COUNTY

Qa

Alluvium

Q

Las Vegas Formation

UNCONFORMITY

Tb | Tv

Volcanic rocks

Tv, undifferentiated volcanic rocks
Tb, Fortification Basalt Member of Muddy Creek Formation

TKgr | TKi | TKc

Intrusive rocks

TKgr, holocrystalline rock, mainly granite, quartz monzonite, granodiorite, and diorite
TKi, undivided porphyritic rocks. Includes granite porphyry, rhyolite, trachydolerite, and other intrusives ranging from basaltic to rhyolitic
TKc, undifferentiated intrusive rocks, mainly quartz monzonite and diorite containing roof pendants of volcanic rock, Paleozoic limestone and dolomite, and Precambrian rocks

CRETACEOUS(?) AND TERTIARY

Ja

Aztec sandstone

ℏcm

Chinle and Moenkopi Formations, undivided

EROSIONAL UNCONFORMITY

Pkt

Kaibab, Toroweap, and Coconino Formations and red beds, undivided

EASTERN CLARK COUNTY

TKg

Gale Hills Formation

Mapped only south of the Muddy Mountains

Kt

Thumb Formation

Mapped only northwest of Boulder Basin. May be correlative with lower part of Gale Hills Formation

Pliocene(?)

Tmc

Muddy Creek Formation

ANGULAR UNCONFORMITY

Th

Horse Spring Formation

TKo

Overton Fanglomerate

ANGULAR UNCONFORMITY

Kbu | Kbl

Baseline Sandstone

Kbu, *upper member*
Kbl, *lower member*

Kwt

Willow Tank Formation

ANGULAR UNCONFORMITY

PPMc

Callville Limestone

Mr

Rogers Spring Limestone

MD

Rogers Spring Limestone and Muddy Peak Limestone, undivided

Grouped only in Frenchman Mountain

Dmp

Muddy Peak Limestone

Mapped only in Virgin and South Virgin Mountains

Pzc

Paleozoic carbonate rocks, undifferentiated

Found only in Muddy Mountains

Pz

Remnants of thrust plate

Paleozoic rocks of Pennsylvanian to Cambrian age. Found only in North Muddy Mountains

QUATERNARY

TERTIARY

CRETACEOUS(?) OR TERTIARY(?)

CRETACEOUS(?)

CRETACEOUS

TRIASSIC JURASSIC(?)

PERMIAN

MISSISSIPPIAN, PENNSYLVANIAN AND PERMIAN

MISSISSIPPIAN

CARBONIFEROUS

DEVONIAN AND MISSISSIPPIAN

DEVONIAN

SILURIAN

ORDOVICIAN

WESTERN CLARK COUNTY

PPMb
Bird Spring Formation

Mm
Monte Cristo Limestone

Lower and Upper Mississippian

MISSISSIPPIAN, PENNSYLVANIAN, AND PERMIAN — CARBONIFEROUS

Ds
Sultan Limestone

Middle and Upper Devonian — DEVONIAN

Sl
Lone Mountain Dolomite
Found only in northern Spring Mountains and west of Dry Lake Valley

SILURIAN

Oep
Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group, undifferentiated
Eureka Quartzite, where present, shown as marker bed. Found only in northern Spring Mountains and west of Dry Lake Valley

Lower, Middle, and Upper Ordovician — ORDOVICIAN

DCg
Goodsprings Dolomite
(Found only in the area west and southwest of Las Vegas)

CAMBRIAN TO DEVONIAN (?)

Cdl
Dolomite and limestone, undivided

Middle and Upper Cambrian

Cq
Quartzite, shale, and limestone, undivided
Includes Tapeats Sandstone, Wood Canyon Formation, Pioche Shale, Lyndon Limestone, Chisholm Shale and Carrara Formation

Lower and Middle Cambrian

CAMBRIAN

pCsj
Stirling Quartzite and Johnnie Formation, undivided

PRECAMBRIAN

UNCONFORMITY

pCu **pCm**
Precambrian rocks
pCu, Precambrian rocks, undivided (mapped separately in the Virgin and South Virgin Mountains)
pCm, Gold Butte Granite of Longwell, gneiss and schist

PRECAMBRIAN

II. GEOLOGY

The Eldorado GRA lies within the Basin and Range Province in southern Clark County, Nevada. The study area includes a large portion of the north-south-trending Eldorado Mountains.

The Eldorado Range contains Precambrian gneiss, schist and granite which have been locally intruded by Lower Tertiary granitic masses. Mid-Tertiary volcanics, ranging in composition from rhyolite to basalt, overlie the older intrusives and basement rocks and are the predominant rock type in the northern half of the study area.

The study area is composed of two complex fault blocks separated by the east-west-trending Nelson Fault located about in the center of the GRA. Numerous north-northwest-trending low angle normal faults which merge at depth into a decollement cut the Tertiary volcanics in the northern Nelson fault block (Anderson, 1971). The area south of the Nelson fault has been uplifted and complexly faulted into several blocks.

It should be noted that the geological map that accompanies this report is taken from Longwell and others (1965) because that map is at the required scale. However, the map of Stewart and Carlson (1978) although at a smaller scale, shows much more detailed geology.

1. PHYSIOGRAPHY

The Eldorado GRA lies within the Basin and Range Province in southern Clark County, Nevada. The study area contains a large portion of the north-south-trending Eldorado Mountain Range which is composed of two complex fault blocks. These blocks are separated by the east-west-trending Nelson Fault in the center of the study area.

Elevations along the crest of the Eldorado Mountains average about 4,000 feet. The eastern flank of the range drains into the Colorado River at an elevation somewhat less than 1,000 feet while the western flank drains internally into Eldorado Valley at an elevation of about 3,000 feet.

The northern "Nelson" block is comprised of numerous north-northwest-trending low angle normal faults which displace the Tertiary volcanic sequences. The area south of the Nelson fault has been uplifted exposing predominantly Precambrian basement rocks.

2. ROCK UNITS

The oldest rocks in the Eldorado GRA are Precambrian gneissic and schistose rocks. These have been intruded by pegmatites and aplite dikes throughout the study area. Unnamed Precambrian porphyritic granites grading into augen gneiss occur in the southwest portion of the study area. Unnamed dioritic gneiss is the youngest Precambrian Formation and crops out south and southwest of Nelson.

The next youngest formation is a Lower Tertiary muscovite granite located in the southern part of the GRA. Subsequently, rapakivi granite with large K-feldsper phenocrysts mantled with oligoclase was emplaced throughout the southern half of the GRA forming the largest area of Tertiary intrusive outcrop. Tertiary hypersolvus granite outcroppings in the Nelson area are the youngest intrusives in the GRA. Altogether, the Tertiary rocks that are intruded into the Precambrian schists make up about half of the exposures in the southern part of the GRA (Stewart and Carlson, 1978).

Large gravity slide blocks of fault and landslide megabreccia are found throughout the southern half of the study area. These blocks contain Precambrian gneisses and intrusives and Tertiary intrusive and volcanic fragments.

A series of mid-Tertiary volcanic flows ranging in composition from rhyolite to basalt overlie the older intrusives and are the predominant rock type in the northern half of the study area.

Patsy Mine volcanics have been divided into three informal parts; the lower and upper parts are predominantly andesite and the middle part is mostly rhyolite. A sequence of pre-volcanic sedimentary rocks of unknown age is included with, but is not considered to be a part of, the Patsy Mine volcanics (Anderson, 1971).

Bridge Spring Tuff crops out as a conspicuous light colored north-trending faulted ridge about 1.5 miles northeast of Nelson. This tuff is a typical ash flow cooling unit about 800 feet thick. The tuff is rhyolitic and contains about 20% phenocrysts consisting of plagioclase, sanidine, pyroxene, biotite, magnetite, and sphere.

Mt. Davis volcanics include a variety of volcanic and clastic rocks ranging in composition from rhyolite to basalt together with beds of tuff, coarse rubble, and landslide debris (Anderson, 1971).

The youngest extrusive formation is an unnamed Late Tertiary basalt flow which occurs in the southeastern corner of the study area near Copper Mountain.

The Late Tertiary Muddy Creek Formation contains mostly lithified detritus derived from the adjacent bedrock highlands. This formation outcrops in Sec. 9 of T 24 S, R 64 E.

Silicified and altered rocks occur along fault zones of recent and Pliocene age to the west of Nelson.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures in the GRA are preserved in the folded Precambrian gneiss and schist complex. Extensive large scale folding, regional metamorphism, and the emplacement of intrusive bodies deformed the Precambrian sedimentary rocks. The north-northwesterly chain-like alignment of the Precambrian blocks, and the steep easterly dips of the compressed Precambrian strata indicate complex large scale folding near the center of a Precambrian anticlinorium (Volborth, 1973). The schistocity generally trends north-northwest parallel to the banding of the gneisses.

Miocene-Pliocene Basin and Range type block faulting has produced the present highly complex mosaic of tilted blocks. Longwell (1963) cites several lines of evidence indicating crustal unrest before, during and after the mid-Tertiary Mount Davis eruptions.

The north-south-trending complex Eldorado fault forms the eastern range front and reportedly may have as much as 15,000 feet of displacement.

The Nelson block north of the Nelson fault zone consists of upthrown blocks of Precambrian gneiss on the east and west with a series of extrusive volcanic rocks downthrown in between. Numerous north-northwest-trending low angle faults which merge into a decollement cut the Tertiary volcanics in this block (Anderson, 1971).

The east-west-trending Nelson fault is a left lateral strike-slip zone of repeated major displacement which seems to have been active before, during and after deposition of the volcanics to the north, and coincident with uplift of the southern block. This fault is traced by a one to two mile wide, seven mile long band of brecciated, fused, silicified and argillized Precambrian rocks.

The area south of the Nelson fault has been uplifted and complexly faulted into several blocks. Numerous north-northwest-trending normal and strike-slip faults parallel the Tertiary andesite, rhyolite, and diabase dike swarms. Easterly trending structures crosscut the regional trending north-south structures creating a "mosaic" which includes the Keyhole Canyon, Eastern Copper Mountain, Knob Hill and Ireteba Peaks fault blocks.

Gravity slide blocks of fault and landslide megabreccia, found throughout the southern portion of the GRA, locally mask the older Tertiary structures. These gravitational slides are dated by Volborth (1973) as being Late Tertiary in age, but may be remnants of Jurassic Laramide Orogeny thrust plates (Longwell, 1951).

4. PALEONTOLOGY

The dominant lithologies within the Eldorado GRA are igneous intrusive and volcanic rocks of early to Middle Tertiary age, unsuited to the preservation of paleontological resources. Precambrian metamorphics, similarly unsuitable for fossils, form the balance of the GRA.

5. HISTORICAL GEOLOGY

A thick sequence of Precambrian sedimentary rocks was folded, metamorphosed and intruded by granitic masses during the Precambrian. The absence of Late Precambrian and Early Paleozoic sediments found in other ranges to the north and west indicates that continental conditions may have prevailed in this area during the Late Precambrian.

Paleozoic and Mesozoic rocks are not present, either because of uplift and erosion in that period, or because they were removed by sweeping overthrusts (Volborth, 1969).

Late Jurassic and Cretaceous Laramide orogenic events caused regional thrust faulting and metamorphism. Longwell (1951) postulates that the megabreccias in the study area may in part be vestiges of Laramide thrust plates. The regional metamorphism probably resulted in the formation of large intrusive granitic plutons, dikes and volcanic activity in the Early-Middle Tertiary.

Tertiary Basin and Range block faulting responsible for the present day topography was superimposed over the Laramide overthrust terrain mainly since the Miocene. Normal faults and left-lateral strike slip faults cut even the most recent volcanic flows, suggesting that tectonic forces are still active in the area.

From the Late Tertiary to the present, blocks of fault and landslide megabreccia have been gravitationally sliding down the present slopes especially in the southeastern part of the GRA.

West of Nelson, fumaroles developed along Pliocene to Recent fault zones and altered and silicified the host rocks.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

The main productive area of the only mining district, the Eldorado Canyon district, is about in the middle of the GRA, between the two WSAs. Scattered mines and prospects as much as ten miles south and southeast of the main area around WSA NV 050-0438 are included in the district. The district is credited with $4.6 million production (about $50 million at 1980s prices), mostly in gold and silver with minor copper, lead and zinc, the main period of production being between 1936 and 1942 (Longwell and others, 1965).

A very few miles southwest of the GRA is the Searchlight district, credited with $6.2 million production of gold, silver, lead and some copper.

The White Cloud property, apparently in Sec. 28, T 27 S, R 64 E, is reported to have produced one ton of beryl-bearing material from a pegmatite (Longwell and others, 1965). It is just west of the south end of WSA NV 050-0438.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

No mines, prospects, mineral occurrences or mineralized areas are known within either WSA. However, several mines and prospects lie very close to the edges of WSA NV 050-0438, on all sides (see Metallic Mineral Occurrences Map).

MILS plots of properties show several mines or prospects within both WSAs. However, the names of these identify them as properties that the basic sources of the MILS data show lying outside the WSAs.

3. Mining Claims

In WSA NV 050-0423 there are patented claims near the southeast corner, in Secs. 24 and 25, T 25 S, R 64 E. Available information shows no diggings in this vicinity, but both Precambrian and Tertiary rocks are present, as well as at least two or three faults (Longwell and others, 1965). There are some unpatented claims along the southern border of the WSA, within the WSA as plotted.

Around WSA NV 050-0438 there are several patented claims, mostly in the vicinity of known old mines or prospects; some of them plot about on the WSA boundary. There are unpatented claims in the northwest and southwest corners of the WSA, also in the vicinity of known mines and prospects. In the northeast corner there are unpatented claims in two adjacent quarter sections, well removed from known prospects.

4. Mineral Deposit Types

In the main part of the Eldorado Canyon district the ore occurs in quartz-calcite veins in Tertiary quartz monzonite (Longwell and others, 1965). In the northern part of the main district, some prospects and/or small mines (in particular, the Patsy mercury mine) are in the Tertiary volcanic rocks that the quartz monzonite intrudes (Longwell and others, 1963). The nature of the veins, as they are described, and the rocks that they lie in, indicate that they are epithermal veins.

The few mines that lie around the edges of WSA NV 050-0438 are described as quartz veins in either quartz monzonite (Tertiary) or Precambrian rocks (Longwell and others, 1965). They, too, probably are epithermal veins.

The presence of presumably epithermal veins in Tertiary quartz monzonite host rocks suggests that the veins are the result of some episode of intrusion and volcanism younger than the episode that produced the quartz monzonite bodies -- because epithermal veins are thought to form at relatively shallow depth while quartz monzonite is thought to form at considerably greater depth. The Patsy mine volcanics are dated at 18.3 m.y., the intrusive rocks at 14.2 m.y., and the Mount Davis volcanics at 12.3 m.y. (Anderson, 1971). It may be that a period of erosion stripped much of the cover off the older rocks before the Mount Davis volcanism, and that the veins are related to the latter event. If so, there may be some similar mineralization hidden beneath the cover of the Mount Davis volcanics north of the main district in WSA NV 050-0423.

Pegmatite dikes similar to the beryl-bearing dike of the White Cloud mine occur at several places in the west side of WSA NV 050-0438 (Volborth, 1973).

5. Mineral Economics

The veins of the Eldorado Canyon district are, for the most part, relatively narrow -- a few feet seems to be average (Longwell and others, 1965). However, they have fairly substantial tonnage and good grade. At the price of gold in the early 1980s small or perhaps medium-sized

mining companies would be interested in mining similar veins if they could be found virgin.

The major use of gold is for storing wealth. It is no longer used for coinage because of monetary problems, but many gold "coins" are struck each year for sale simply as known quantities of gold that the buyer can keep or dispose of relatively easily. The greatest other use of gold is in jewelry, another form of stored wealth. In recent years industrial applications have become increasingly important, especially as a conductor in electronic instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twelve of which make one troy pound. Annual world production is about 50 million ounces per year, of which the United States produces somewhat more than one million ounces, less than one-fourth of its consumption, while the Republic of South Africa is by far the largest producer at more than 20 million ounces per year. World production is expected to increase through the 1980s. For many years the price was fixed by the United States at $35 per ounce, but after deregulation the price rose to a high of more than $800 per ounce then dropped to the neighborhood of $400 per ounce. At the end of 1982 the price was $460.50 per ounce.

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a by-product in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

About 80 percent of beryllium is used in alloys, mostly with copper, and most of the alloys are used in electrical applications such as springs, contacts, relays and other equipment. Some is used in aerospace applications, either in alloys or as beryllium metal which has high strength, light weight and excellent anticorrosion characteristics. The United States consumes about 300 tons of beryllium annually, probably more than half of which is produced domestically. Beryllium consumption is not expected to change greatly by the year 2000, partly because it can be highly toxic especially while being processed, so other materials are used in its stead wherever possible. The mineral beryl, which contains about 11 percent beryllium

oxide and is one of the major ores of beryllium, is priced at about $475 per ton, though all sales are negotiated. Some beryl is used as a semi-precious gemstone, and one variety, the emerald, is highly prized.

B. NONMETALLIC MINERALS

1. Known Mineral Deposits

No nonmetallic mineral deposits are known in the Eldorado Mountains GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

The White Cloud pegmatite dike, described under Metallic Minerals, is indicated by Longwell and others (1965) to also contain mica; there is no mention of any mica production nor any indication as to the quality of the mica.

No other prospects, mineral occurrences or mineralized areas of nonmetallic minerals are known in the GRA.

3. Mining Claims, Leases and Material Sites

It has not been possible to distinguish claims that might have been located for nonmetallic minerals from those located for metallic minerals. There are no mineral leases in the GRA, and no material sites are known in either of the WSAs.

4. Mineral Deposit Types

The known beryl and mica deposit is in a pegmatite dike, and any other deposits of these minerals in the GRA almost certainly will also be in pegmatite dikes.

5. Mineral Economics

Large deposits of beryllium-bearing minerals are known elsewhere in the United States; these are the subject of interest (and in some cases mining) by major companies. It is unlikely that the pegmatites of the Eldorado Mountain GRA could be mined as sources of the metal beryllium. Possibly they might be mined for beryl as an industrial mineral or, if of good enough quality, as a semi-precious stone, on a small scale. If the mica in them is of good quality, it might be mined from them under circumstances that precluded importation of mica -- nearly all is presently imported.

About 80 percent of beryllium is used in alloys, mostly with copper, and most of the alloys are used in electrical applications such as springs, contacts, relays and other equipment. Some is used in aerospace applications, either in alloys or as beryllium metal which has high strength, light weight and excellent anticorrosion characteristics. The United States consumes about 300 tons of beryllium annually, probably more than half of which is produced domestically. Beryllium consumption is not expected to change greatly by the year 2000, partly because it can be highly toxic especially while being processed, so other materials are used in its stead wherever possible. The mineral beryl, which contains about 11 percent beryllium oxide and is one of the major ores of beryllium, is priced at about $475 per ton, though all sales are negotiated. Some beryl is used as a semi-precious gemstone, and one variety, the emerald, is highly prized.

Sheet mica, which can be split into sheets with more than about one square inch of area, is used because of its electrical and thermal insulating properties in electrical and electronic applications and in high-temperature situations such as stove and microwave oven windows and hair dryer elements. Scrap or flake mica, which is ground to a fine powder, is used in plasterboard cement, as a coating on rolled roofing and asphalt shingles, as a paint pigment, and as a filler in rubber and plastics. The United States uses about 5 million pounds of sheet mica annually and produces almost none; sheet mica is listed as a strategic and critical mineral. The country uses somewhat more than 100 million short tons of flake mica annually, and produces more than it consumes. United States consumption of sheet mica is forecast to decline somewhat by the year 2000, while production will remain almost zero. Consumption of flake mica will nearly double by the year 2000, and domestic production will keep up with the demand. The price of sheet mica is about $6 per pound, while the price of flake mica is about $50 per short ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

   There are no known uranium or thorium deposits within or near the WSAs or the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are two uranium occurrences within the GRA, one on the southeast border of WSA NV 050-0423 and one on the western border of WSA NV 050-0438 (see Uranium Land Classification and Mineral Occurrence Map). There are also two uranium occurrences just west of the GRA. All four of these occurrences are in Precambrian rocks (Garside, 1973).

The uranium occurrences are tabulated below:

Big Horn Claims
Sec. 36(?), T 25 S, R 64 E

H & E Property
SW/4, Sec. 4, T 27 S, R 64 E

M & E Nos. 2 and 12 claims
Sec. 35(?), T 25 S, R 63 E

Mary Helen and Rose Alice claims
Sec. 14(?), T 26 S, R 63 E

3. Mining Claims

The only known uranium claims within or near the GRA are those listed above and these have probably lapsed. There are no known thorium claims within or near the GRA.

4. Mineral Deposit Types

The lack of known uranium or thorium deposits in the area prevents a discussion of deposit types.

5. Mineral Economics

Uranium and thorium do not appear to have much economic value in the area as there are no significant deposits within or near the GRA.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based

on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a by-product of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear power reactor usage, assuming that six to ten thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequacy of thorium reserves. The United States has reserves estimated at 218,000 tons of THO in steam and beach placers, veins and carbonatite deposits (Kirk, 1982); and probably cumulative demand in the United States as of 2000 is estimated at only 1,800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

Oil and Gas Resources

1. Known Oil and Gas Deposits

There are no known oil and gas deposits in the GRA.

2. Known Prospects, Oil and Gas Occurrences and Petroliferous Areas

No oil seeps are present in the GRA, but eleven miles west of the GRA the Oscar Bray No. 1 was drilled to 840 feet in 1961(?). No oil or gas shows were reported in this well (Nevada Bureau of Mines and Geology Oil and Gas Files, 1982).

3. Oil and Gas Leases

Federal oil and gas leases cover whole townships in the immediate region and nearly 29 sections in the GRA, but only one in WSA 050-0438 and two in WSA 050-0423.

4. Oil and Gas Deposit Types

Oil deposits that have been found and developed, and those that are being explored for in the Basin and Range to date, have been limited to the Upper Paleozoic section of the miogeosyncline and the Tertiary section of the intermontane basins. The source rocks are assumed to be in Paleozoic horizons, such as the Mississippian Chainman Shale, and perhaps also the Tertiary section.

The reservoirs at the Trap Spring and Eagle Springs oil fields in Railroad Valley are the Oligocene Garrett Ranch volcanics or equivalent, which produce from fracture porosity; or the Eocene Sheep Pass Formation, a freshwater limestone. Minor production has been recorded from the Ely(?) Formation of Pennsylvanian age at Eagle Springs. It may be that production also comes from other units in the Tertiary or Paleozoic sections in the Blackburn oil field in Pine Valley or the Currant and Bacon Flat oil fields in Railroad Valley.

The GRA is within or close to the North American Overthrust Belt which has good oil and gas production in Wyoming/Utah, Mexico and Canada (Oil and Gas Jour., May 12, 1980). The Federal leases in Nevada are for rank wildcat acreage, and surficial stratigraphic units do not necessarily have a direct bearing on possible drilling objectives at depth, considering overthrust structural implications.

Recent seismic surveys (e.g., Seisdata Services, 1981; Geophysical Service Inc., 1981; GeoData, 1981: Index maps in GRA File) indicate, in part, the general area of industry interest. This and certain other data may be purchased, but deep exploratory test data are not readily available. Published maps of the Overthrust Belt in Nevada are very generalized, and are not necessarily in agreement because exploration is at an early stage (Oil

and Gas Jour., May 12, 1980; Western Oil Reporter, June, 1980; Keith, 1979: Index maps in GRA File).

5. Oil and Gas Economics

The low level of production from Nevada Basin and Range oil fields, which are remote from existing pipelines, existing refineries and consuming areas, necessitates the trucking of the crude oil to existing refineries in Utah, California and Nevada. Since the discovery of oil in Nevada in 1953, the level of production has fluctuated. Factors which have affected the production from individual wells are: reservoir and oil characteristics; Federal regulations; productivity; environmental constraints; willingness or ability of a refiner to take certain types of oil; and of course, the price to the producer, which is tied to regional, national and international prices.

Geothermal Resources

1. Known Geothermal Deposits

There are no known geothermal deposits in the GRA.

2. Known Prospects, Geothermal Occurrences and Geothermal Areas

No prospects, occurrences or thermal areas are known to be present in the GRA, however, a single well with water of 83°F is located in the valley five miles to the west of the GRA (see Geothermal Occurrence and Land Classification Map).

3. Geothermal Leases

There are no geothermal leases on Federal lands in the GRA or vicinity.

4. Geothermal Deposit Types

Geothermal resources are hot water and/or steam which occurs in subsurface reservoirs or at the surface as springs. The temperature of a resource may be about 70°F (or just above average ambient air temperature) to well above 400°F in the Basin and Range province.

The reservoirs may be individual faults, intricate fault-fracture systems, or rock units having intergranular permeability -- or a combination of these. Deep-seated normal faults are believed to be the main conduits for the

thermal waters rising from thousands of feet below in the earth's crust.

The higher temperature and larger capacity resources in the Basin and Range are generally hydrothermal convective systems. The lower temperature reservoirs may be individual faults bearing thermal water or lower pressured, permeable rock units fed by faults or fault systems. Reservoirs are present from the surface to over 10,000 feet in depth.

5. Geothermal Economics

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year-round mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is an historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

No other geological resources are known in the Eldorado Mountains GRA.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical mterials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

At least one pegmatite body very close to WSA NV 050-0438 has produced some beryl and is reported to contain mica. Other pegmatite bodies lie within the WSA. Beryllium, which can be extracted from the mineral beryl, is a strategic metal, and sheet mica is a strategic and critical mineral. It is not known if the pegmatite mica is of sheet quality.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES POTENTIAL

Anderson (1971) provides good geological mapping of the western part of WSA NV 050-0423, and Stewart and Carlson (1978) provide nearly as good coverage in the eastern part although at a small scale. Volborth provides good mapping of all of WSA NV 050-0438. All three works apparently directed little attention toward possible alteration that might be associated with mineralization. There is very little information available about the nature of prospects and mineralization occurrences known to be in or very close to the WSAs. Overall, the quantity of geological data is moderately high, as is its quality, except for the apparent lack of data on alteration. The quantity of data on mineralization is low, as is its quality. We have high confidence in the available geological data but low confidence in the data pertaining to mineralization.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g., M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside a WSA has been used in establishing a classification area within a WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA NV 050-0423

M1-2B. This classification area covers part of the southern edge of the WSA. In it are exposed the Tertiary intrusive bodies in which the ore of the Eldorado Canyon is reported to occur, and the Precambrian rocks that they intrude: the rocks that are known to be old enough to host veins of the kind known in the Eldorado Canyon district. The classification of low favorability, and the low confidence level, stem from the fact that no mines or prospects are known in this part of the WSA (although there are unpatented claims), but productive mines lie a very short distance outside the WSA.

M2-2A. This classification area covers the remainder of the WSA. In it the surface is all Tertiary volcanic rocks. The age of these volcanics, relative to the age of the Tertiary intrusive rocks that are the host for the Eldorado Canyon district deposits, is not known with certainty. It is possible that the volcanic rocks are younger than the intrusives and younger than the ore deposits in them, and therefore may be covering similar deposits. This is the reason for the low favorability classification, and the very low confidence level.

WSA NV 050-0438

M3-3B. This classification area covers a small part of the northwest corner of the WSA. Just outside the WSA is the Belmont-Phoenix mine, which is credited with something less than $100,000 production (Longwell and others, et. al., 1965), and within the WSA are unpatented claims that suggest there are at least some prospects and mineralization. The silver production, and the indicated mineralization within the WSA, are the reasons for the moderately favorable classification and the low confidence level.

M4-2A. This classification area covers the remainder of the WSA. Prospects and claims lie very close to the WSA boundary in all directions, and locally claims lie within the WSA. There are extensive areas of Tertiary intrusive rocks in the WSA that could have served as the source for mineralizing solutions. These are the reasons for the low favorability and the low confidence in it.

b. Uranium and Thorium

WSA NV 050-0423 and 050-0438

U1-3C. This land classification area covers essentially all of both of the WSAs. Uranium has moderate favorability with moderate confidence and thorium has low favorability with low confidence in the area. There are two uranium occurrences within the GRA. The Big Horn claims in Sec. 36(?), T 25 S, R 64 E are on the southeastern border of WSA NV 050-0423 and the H & E Property in Sec. 4, T 27 S, R 64 E is on the western border of WSA NV 050-0438. Radioactivity occurs in fractures in Precambrian metamoprhic rocks at these sites.

Possible source rocks for the uranium and thorium are the Precambrian granites and pegmatites which have intruded the Precambrian metamorphic rocks, and the Tertiary granitic intrusives. The Tertiary volcanics in the northern part of the GRA are also a possible uranium source.

Uranium apparently does occur as fracture fill deposits within the WSAs though it could also occur as vein type deposits and primary mineral concentrations in pegmatites. Thorium would most likely be restricted to mineral concentrations in pegmatites within the WSAs.

WSA NV 050-0438

U2-2B. This land classification covers a small part of the WSA which is covered by Quaternary alluvium. Uranium has a low favorability with low confidence for concentration in the area, as epigenetic sandstone type deposits. Both thorium and uranium have low favorability with low confidence as resistate mineral concentrations in stream sands in the area.

c. Nonmetallic Minerals

WSA NV 050-0423

N1-2B. This classification area covers all of the WSA. No nonmetallic mineral deposits or prospects are known in or near the WSA, but practically any mineral material can be used for something -- all that is required to make it saleable is someone with the acuteness to find the market. This is the reason for the low favorability and the low level of confidence.

WSA NV 050-0438

N2-2B. This classification area covers a strip along the western edge of the WSA. In it, Volborth (1972) maps pegmatite dikes. At its extreme south end is the White Cloud mine in pegmatite, which has produced some beryl and is reputed to contain mica. Whether beryl or mica are present in the other dikes is not known. These are the reasons for the low favorability, and the low level of confidence. It should be noted that beryl (as the metal beryllium) is a strategic metal, and mica is a strategic and critical mineral.

N3-2B. This classification area covers the remainder of the WSA. The rationale for the low favorability classification and low level of confidence are the same as for N1-2B.

2. LEASABLE RESOURCES

a. Oil and Gas

WSAs NV 050-0423 and NV 050-0438

OG1-2A. The lack of exploratory drilling inhibits a good resource assessment of the GRA. The presence of Precambrian and Tertiary/Cretaceous granitic rocks underlying WSA 050-0438 and Tertiary/Cretaceous intrusives under WSA 050-0423 would normally require a 1D classification for these areas. However, industry exploration of the Overthrust Belt in this area indicates these rock units may be shallow, and actually be overlying potential exploration targets at considerable but drillable depths. The presence of leaseholds in the two WSAs supports this reasoning at present. This is the reason for the low favorability and the very low level of confidence.

b. Geothermal

WSA NV 050-0423

G1-2A. This WSA incorporates an intricately faulted section of Tertiary volcanics and smaller Tertiary intrusives. The structure present is similar to that in much of the rest of the Basin and Range province where segments of the deep-seated normal faults provide the fracture permeability which allows thermal water to rise to the surface or near-surface. The waters, if present, would probably be in the low-temperature range.

WSA NV 050-0438

G2-1A. This area is underlain by Precambrian rock which is mapped as not being host to the deep-seated-type normal faults necessary to act as passages for rising thermal waters. The WSA is not favorable, but the level of confidence is very low.

c. Sodium and Potassium

S1-1D. There is no known potential for sodium and potassium in the WSA. No map is presented for sodium and potassium.

3. SALEABLE RESOURCES

Saleable resources have been covered in the section on Nonmetallic Minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

1. The BLM records should be examined to determine where the patented claims in Secs. 25 and 26, T 25 S, R 64 E lie with respect to the boundary of WSA NV 050-0423.

2. WSA NV 050-0423 should be reconnoitered to determine if there is alteration in the volcanic rocks that might indicate mineralization at depth -- the presence of the Patsy mercury mine west of the WSA suggests this may be possible. Existing mapping was done before alteration received much attention in general mapping projects.

3. The presence of small clusters of unpatented claims in the northwest and southwest corners of WSA NV 050-0438 suggest that there may be altered or weakly mineralized zones adjacent to the known mines and prospects there. This should be checked in the field.

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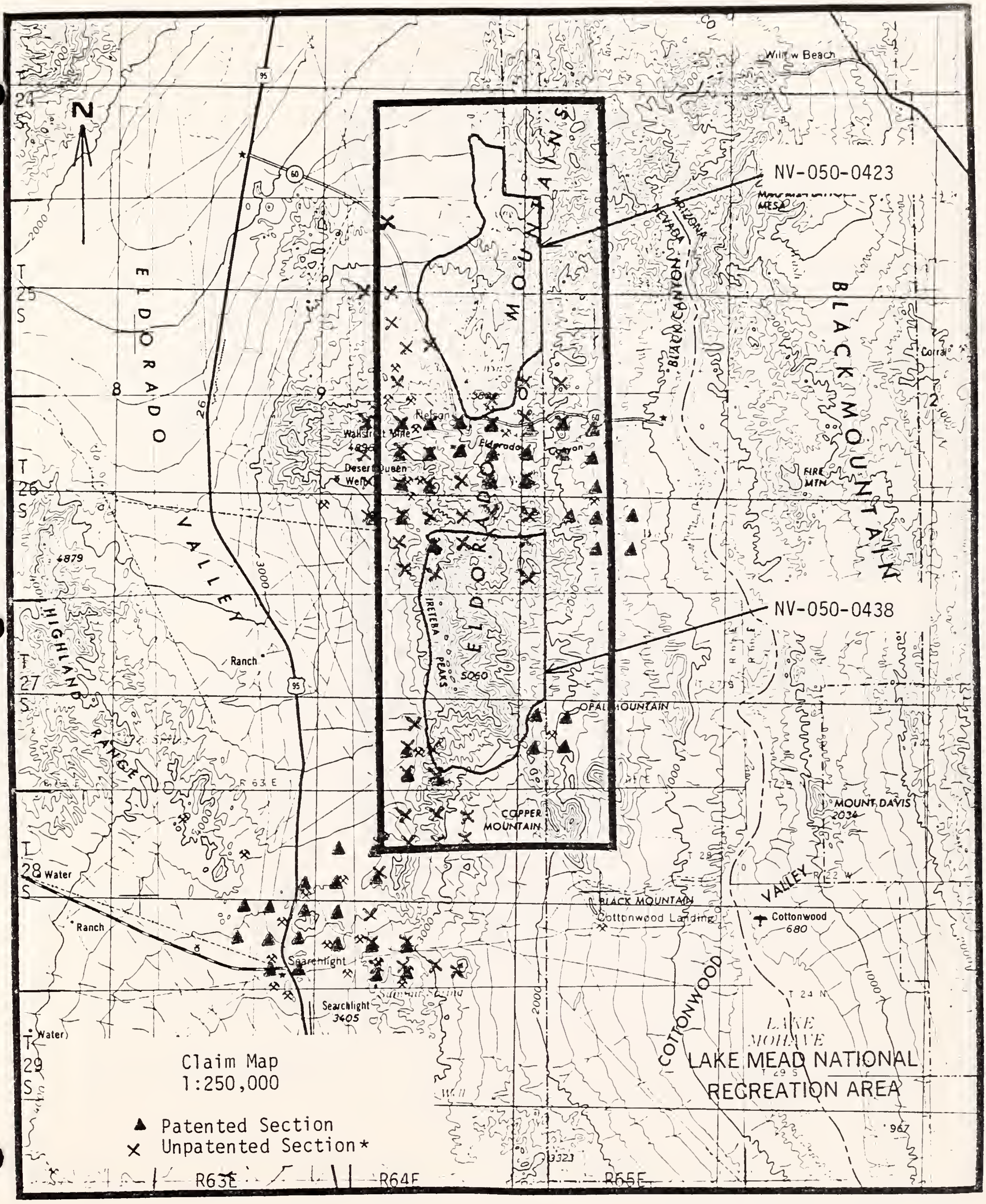
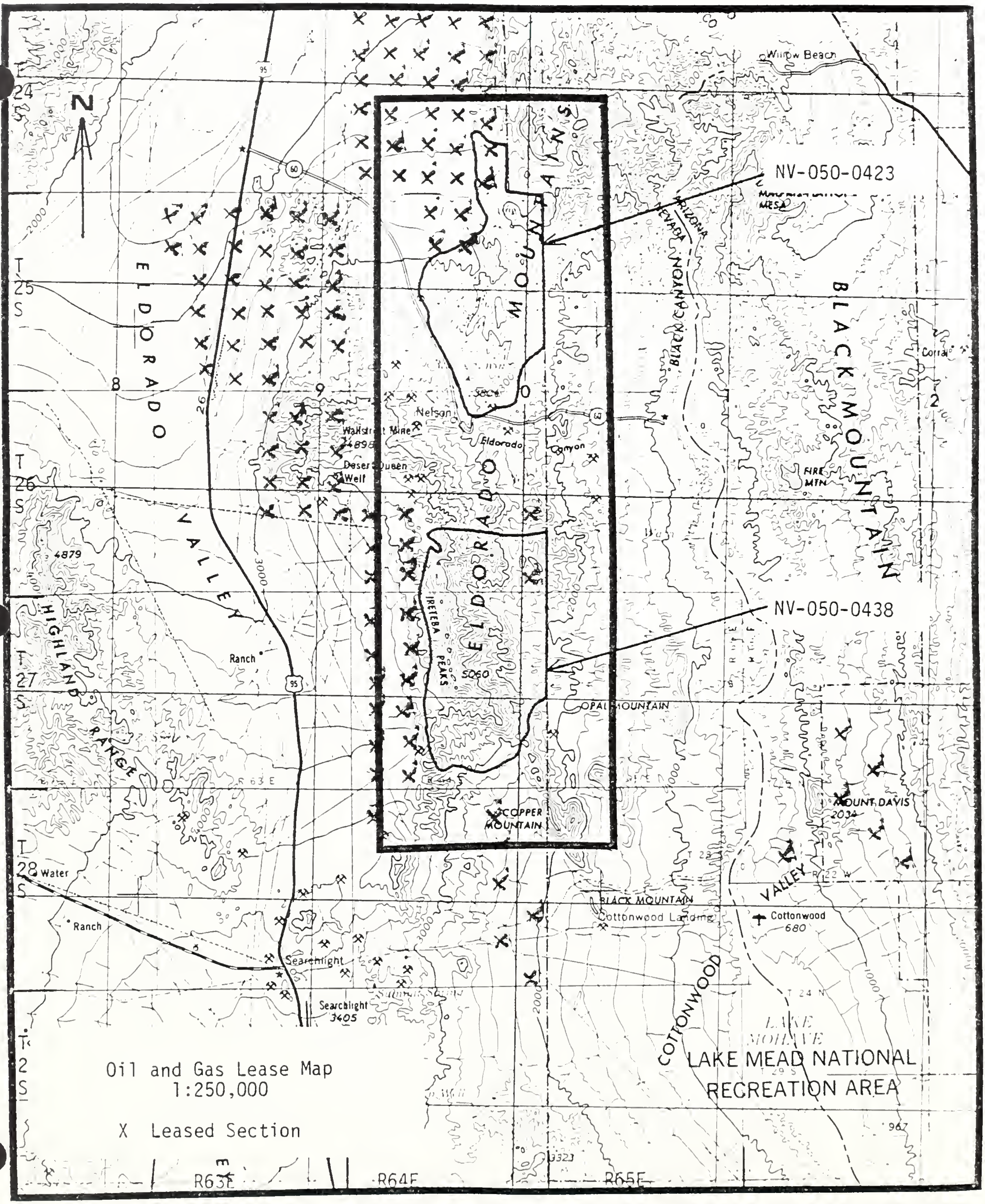
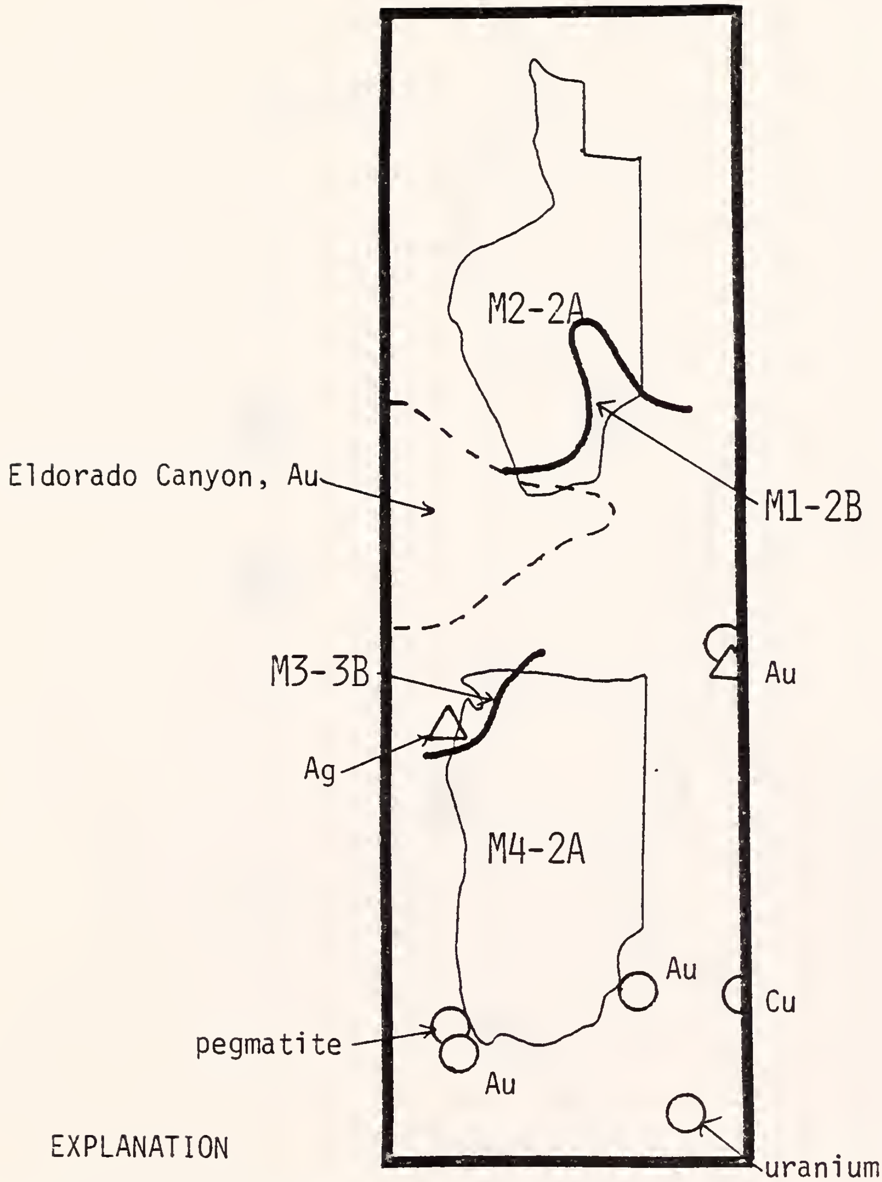


*X denotes one or more claims per section


NV-050-0423
NV-050-0438
ELDORADO MOUNTAINS
ELDORADO VALLEY
BLACK MOUNTAIN
BLACK CANYON
HIGHLAND RANGE
IRETEBA PEAKS
COPPER MOUNTAIN
OPAL MOUNTAIN
Nelson
Eldorado Canyon
Searchlight
Cottonwood Landing
MOUNT DAVIS
COTTONWOOD VALLEY
LAKE MEAD NATIONAL RECREATION AREA
Willow Beach
R63E
R64E
R65E
Oil and Gas Lease Map
1:250,000
X Leased Section



EXPLANATION

- - - Mining District, commodity

△ Mine, commodity

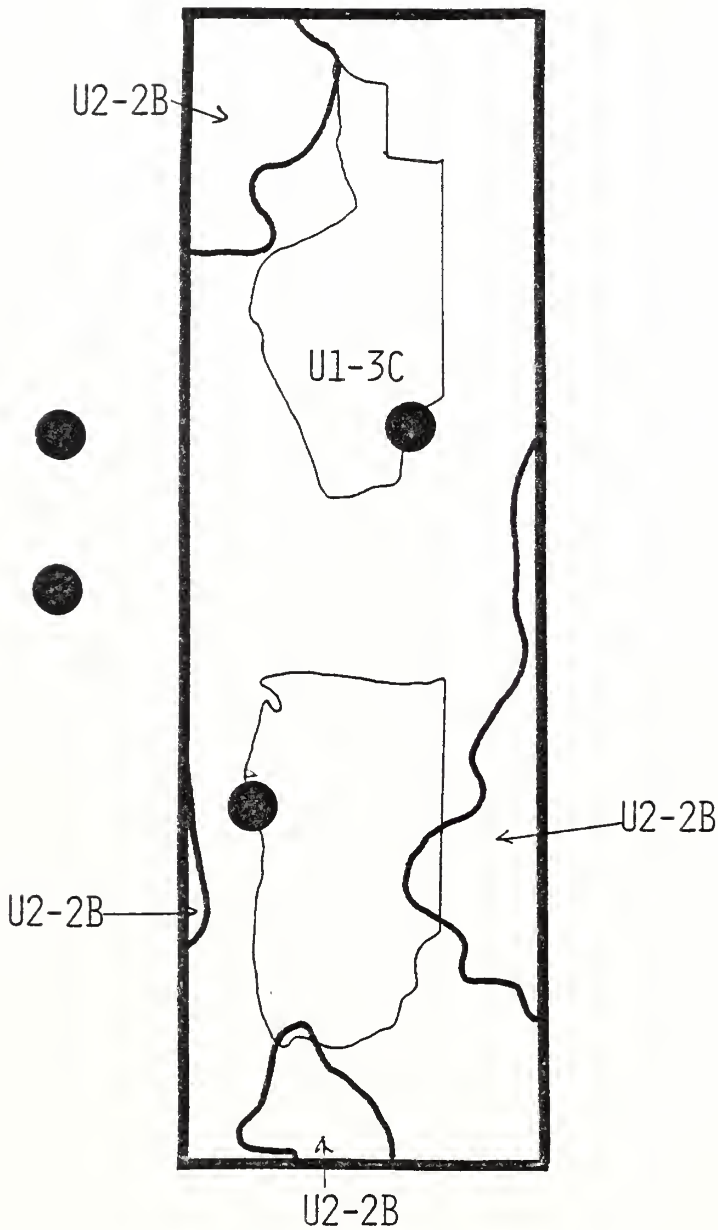
○ Occurrence, commodity

━━ Land Classification Boundary

── WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics

Eldorado Mountains GRA NV-3
Scale 1:250,000



EXPLANATION

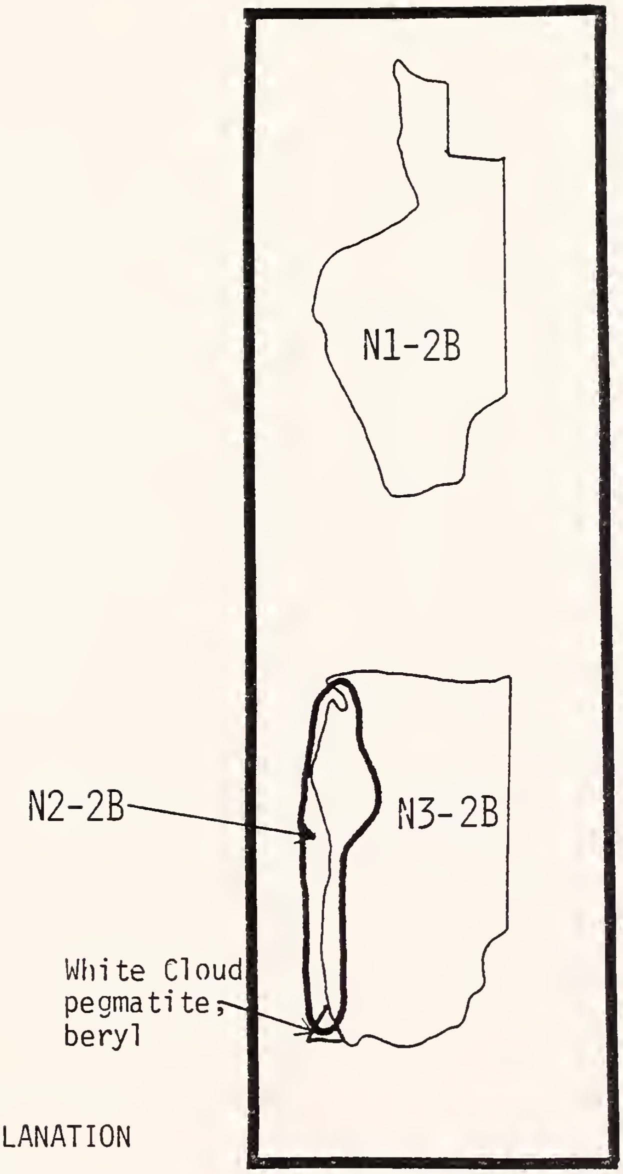
Uranium Occurrence

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium

Eldorado Mountains GRA NV-37
Scale 1:250,000



EXPLANATION

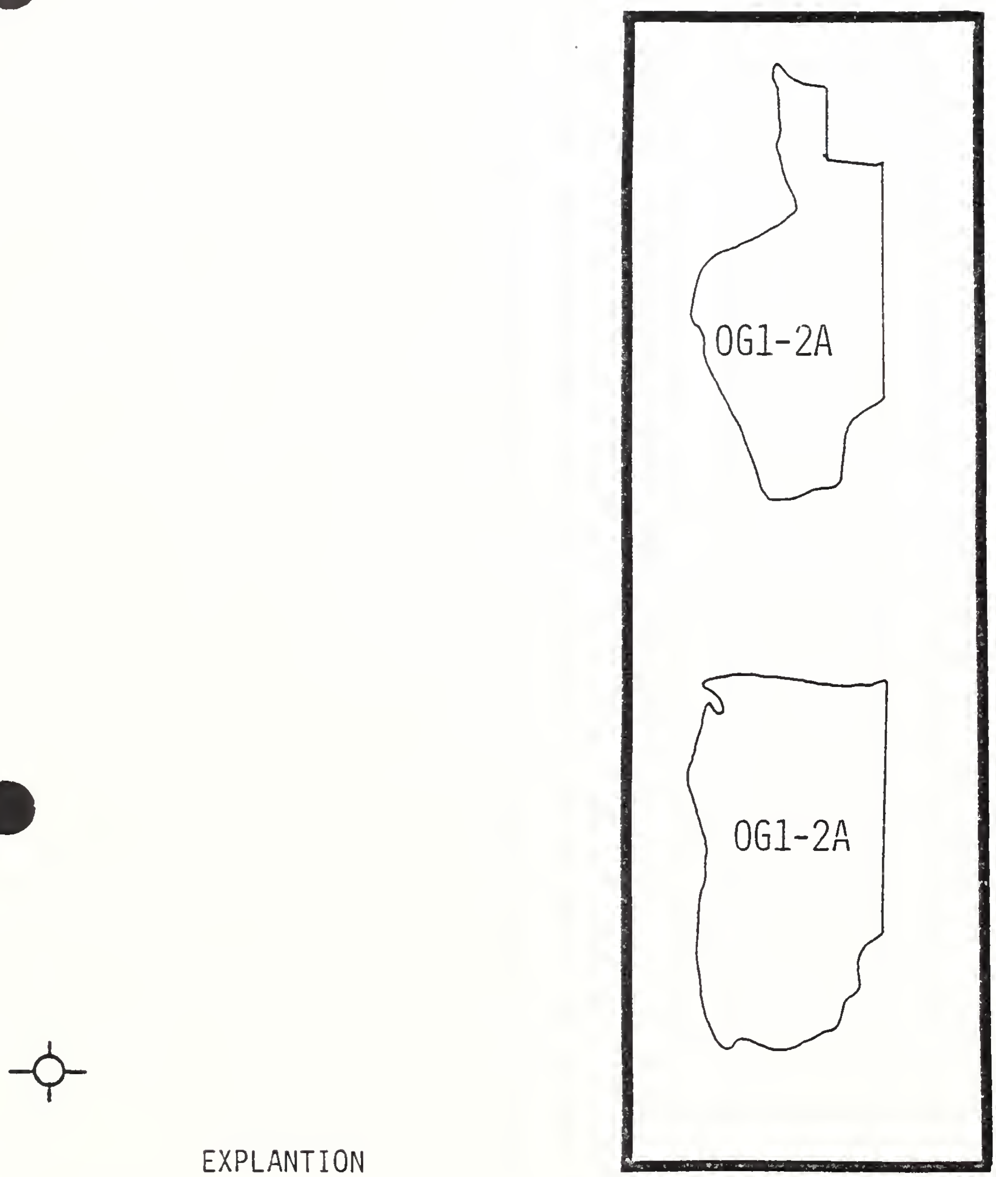
△ Mine, commodity

▬ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics

Eldorado Mountains GRA NV-3
Scale 1:250,000



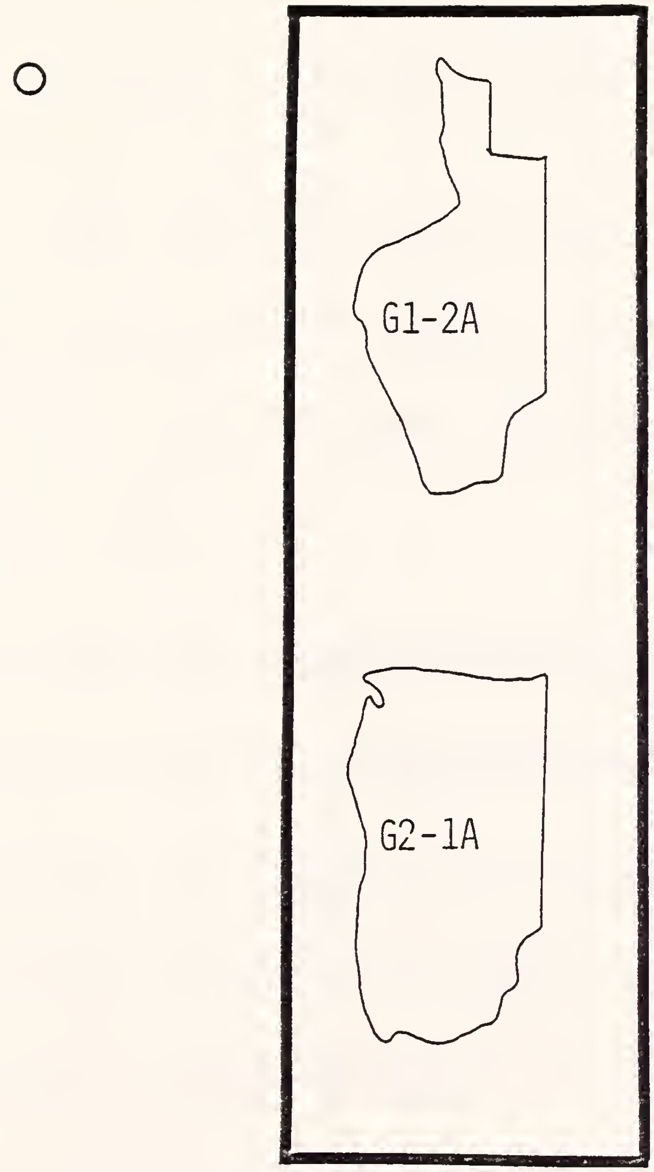
EXPLANTION

Dry hole

WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Oil & Gas

Eldorado Mountains GRA NV-3?
Scale 1:250,000



EXPLANATION

○ Thermal Well

— WSA and Land Classification Boundary

Eldorado Mountains GRA NV-37
Scale 1:250,000

Land Classification - Mineral Occurrence Map/Geothermal

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems: Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Carboniferous Systems: Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene, and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1087, for the Pleistocene of southern California.

[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian.

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970